

UNITED STATES DISTRICT COURT  
WESTERN DISTRICT OF TEXAS  
SAN ANTONIO DIVISION

WAVE NEUROSCIENCE, INC.,

Plaintiff,

vs.

BRAIN FREQUENCY LLC,

Defendant.

Civil Action No. 5:23-cv-00626-XR

**Demand for Jury Trial**

**DECLARATION OF DR. JARED DEMPSEY'S IN SUPPORT OF DEFENDANT'S  
MOTION FOR SUMMARY JUDGMENT OF INVALIDITY UNDER 35 U.S.C. §101**

1. I, Jared Dempsey, hereby declare under penalty of perjury that the facts set forth herein are true and correct to the best of my knowledge and belief, and, if called as a witness, I can and will testify at trial as to the matters discussed in this disclosure of testimony.

2. I have previously submitted two declarations (Dkts. 34-1 and 49-1) in this matter, pertaining to claim construction issues of the Asserted Patents. The "Asserted Patents" are U.S. Patent No. 8,926,490 ("490 Patent"), No. 8,465,408 ("408 Patent"), and No. 8,870,737 ("737 Patent"). I understand that the Court has rejected Plaintiff Wave Neuroscience's arguments that I do not qualify as a POSITA in the relevant field. (Dkt. 53). I fully incorporate my specific qualifications relevant to this matter disclosed in my prior two declarations herein.

3. I submit this declaration in support of Defendants motion concerning the patentability of the Asserted Patents. I understand from Defendant's counsel that the earliest

priority date of the Asserted Patents is no earlier than Sep. 24, 2008 for the '490 and '737 Patents based on their common parent application No. 12/237,328, now Pat. No. 8,480,554 (invalidated in PeakLogic); and Aug. 6, 2009 for the '408 Patent based on its provisional application No. 61/231,928.

4. I have reviewed the *Declaration Of Martijn Arns, PhD. In Support Of Defendants' Motion For Summary Judgment Of Invalidity*, filed in *Wave Neuroscience, Inc. v. PeakLogic, Inc.*, Case No. 3:21-cv-01330-CAB-SBC, Dkt. 207-2. Dr. Arns declaration is relevant here because the same technology is at issue in this case. Indeed, I have been informed by Defendant's counsel that the patents discussed by Dr. Arns are in the same patent families as two of the patents I am considering here: the asserted '490 Patent is a continuation-in-part of the invalidated '554 Patent, and the asserted '737 Patent claims priority from the same provisional application (61/260,779) as the invalidated '259 Patent. I have further been informed by Defendant's counsel that the PeakLogic Court later vacated its invalidation order on procedural grounds that did not pertain to the technical analysis provided by Dr. Arns. That later order does not affect my analysis which focuses solely on the technical aspects of the patents at issue in this matter.

5. I agree with Dr. Arns' representations and analysis fully, and have incorporated the relevant portions thereof in my instant declaration. Everything set forth in my declarations, including portions adopted from Dr. Arns' declaration, accurately set forth my expert opinion, and I am available to testify truthfully and accurately thereto to the best of my ability.

6. The purpose of this declaration is to present facts regarding the existence, publication dates, and content of scientific literature, as well as to provide my expert opinions on the meaning and interpretation of that literature in the context of the patent claims at issue.

## **THE HUMAN BRAIN**

7. The human nervous system is made up of microscopic cells called neurons. These neurons, especially pyramidal neurons, carry electrical pulses called action potentials that give rise to post-synaptic ionic current flow referred to as excitatory or inhibitory post-synaptic potentials (EPSP or IPSP respectively). The coordinated summation of EPSPs and IPSPs across cortical neuronal clusters generates field potentials, which contribute to the wave-like activity measured outside the skull as electroencephalographic (EEG) signals..<sup>1</sup> EEG activity primarily reflects rhythmic and sinusoidal patterns of brain activity, though it can also include irregular or transient components. Like any repeated event, these oscillatory patterns occur at specific frequencies, expressed in Hz..<sup>2</sup>

8. Individual neurons firing in the human brain—and their associated field potentials—do not fire at a uniform frequency; rather, at any given time, different neurons and groups of neurons are simultaneously firing at different times and frequencies (*e.g.* delta, theta and alpha; but also at different frequencies within a band, *e.g.* the alpha band), and the frequencies are changing, moment to moment..<sup>3</sup> When multiple neurons are grouped together—as in physical areas of the brain which contain billions of individual neurons—neurons tend to fire synchronously such that many of the neurons fire at approximately the same time, and the cumulative effect of these field potentials are detectable as electrical signals commonly known as “brainwaves.” Brainwaves

---

<sup>1</sup> Ex. 2 (Speckmann, Erwin-Josef et al., *Introduction to the Neurophysiological Basis of the EEG and DC Potentials*, ELECTROENCEPHALOGRAPHY: BASIC PRINCIPLES, CLINICAL APPLICATIONS, AND RELATED FIELDS Chap. 2, 15-27 (Lippincott Williams & Wilkins, 4th ed. 1999)).

<sup>2</sup> Ten (10) firings per second is equivalent to 10 Hz.

<sup>3</sup> Ex. 4 (Steriade, Mircea, *Cellular Substrates of Brain Rhythms*, ELECTROENCEPHALOGRAPHY: BASIC PRINCIPLES, CLINICAL APPLICATIONS, AND RELATED FIELDS, Chap. 3, 28-75 (Lippincott Williams & Wilkins, 4th ed. 1999) (“Steriade”)).

can be measured using electroencephalography (“EEG”)<sup>4</sup> and EEG measurements in turn exhibit frequencies. These naturally occurring frequencies exhibited by brainwaves, which arise from different parts of the human brain, are referred to as the brain’s “intrinsic frequencies.” In humans, brainwaves are typically grouped and categorized by the frequency bands in which they occur. There are many human brainwave frequency bands, including but not limited to alpha (8-13 Hz), delta (1-4 Hz), and theta (4-7 Hz).<sup>5</sup> Of particular interest in this case are alpha waves, which were discovered by Hans Berger, the inventor of the human EEG, in 1924 (and published in 1929).<sup>6</sup>

### **BRAIN ENTRAINMENT**

9. The term “entrainment” describes a shared tendency of many physical and biological systems to synchronize their periodicity and rhythm through interaction. The physics concept of entrainment was already described by Dutch Physicist Christiaan Huygens in 1665, who observed that the sway of two pendulums mounted on the same support became synchronized in phase and frequency. This synchronization occurs because small amounts of energy are transferred between the systems when they are out of phase, creating negative feedback that stabilizes their phase relationship. As they assume a more stable phase relationship, the amount of energy gradually reduces to zero, with systems of greater frequency slowing down, and the other speeding up. Scientists have long known and observed that, when the brain is stimulated by an external rhythm, the neurons in the brain attempt to synchronize their firing with external rhythmic stimulus. This concept is called entrainment and was first described in 1934 by Adrian and

---

<sup>4</sup> See Ex. 3 (EEG (electroencephalogram), <https://www.mayoclinic.org/tests-procedures/eeeg/about/pac-20393875> (last visited Feb. 6, 2025)).

<sup>5</sup> Ex. 4 (Steriade).

<sup>6</sup> Ex. 5 (Ince, Rumeysa et al., *The inventor of electroencephalography (EEG): Hans Berger (1873-1941)*, 37 CHILD’S NERVOUS SYSTEM 2723-24 (2021)).

Matthews (“Adrian and Matthews”).<sup>7</sup> The Adrian and Matthews report demonstrated that the brain’s intrinsic frequency in the visual cortex—as measured using EEG—could be entrained to the same frequency as a visual flicker applied externally. Similar results have been found for other rhythmic stimuli, such as acoustic stimuli (*i.e.*, sounds).<sup>8</sup> Scientists have also established that changes to the brain’s intrinsic frequencies may be made by applied electromagnetic fields, such as those generated by mobile phones.<sup>9</sup>

### **REPETITIVE TRANSCRANIAL MAGNETIC STIMULATION (“rTMS”)**

10. Transcranial Magnetic Stimulation (or “TMS”) is a non-invasive method of affecting the brain.<sup>10</sup> “Magnetic” means that the stimulation is accomplished through magnetic pulses or magnetic fields, rather than, for example, surgery or electrical shocks. “Transcranial” refers to the fact that the magnetic fields pass through the cranium (or skull) of the subject to affect the brain of the subject. And “stimulation” simply means that the magnetic field and/or pulses act on the brain in some fashion.

---

<sup>7</sup> Ex. 6 (Adrian, E.D. & Matthews, B.H.C., *The Interpretation of Potential Waves In The Cortex*, 81 *The Journal of Physiology* 440-71 (1934) (“Adrian & Matthews”)).

<sup>8</sup> See Ex. 7 (Will, Udo & Berg, Eric, *Brain Wave synchronization and entrainment to periodic acoustic stimuli*, 424 *Neuroscience Letters* 55-60 (2007) (“Will & Berg”)).

<sup>9</sup> See, e.g., Ex. 8 (Gavalas, R.J. et al., *Effect of Low-Level, Low-Frequency Electric Fields on EEG and Behavior in Macaca Nemestrina*, 18 *BRAIN RESEARCH* 491-501 (1970) (“Gavalas”)); Ex. 9 (Bawin, S.M. et al., *Effects of Modulated Very High Frequency Fields on Specific Brain Rhythms in Cats*, 58 *BRAIN RESEARCH* 365-84 (1974) (“Bawin”)); Ex. 10 (Bell, Glenn B. et al., *Frequency-specific Responses in the Human Brain Caused by Electromagnetic Fields*, 123 *JOURNAL OF THE NEUROLOGICAL SCIENCES* 26-32 (1994) (“Bell”)); Ex. 11 (Cook, Charles M. et al., *Resting EEG Effects During Exposure to a Pulsed ELF Magnetic Field*, 26 *BIOELECTROMAGNETICS* 367-76 (2005) (“Cook”)); Ex. 12 (Arns, Martijn et al., *Electroencephalographic, Personality, & Executive Function Measures Associated with Frequent Mobile Phone Use*, 117 *Int’l Journal of Neuroscience* 1341-60 (2007; received June 1, 2006) (“Arns 2006”)).

<sup>10</sup> See Ex. 13 (Klimesch, Wolfgang et al, *SHORT COMMUNICATION: Enhancing cognitive performance with repetitive transcranial magnetic stimulation at human individual alpha frequency*, 17 *EUROPEAN JOURNAL OF NEUROSCIENCE*, 1129-33 (2003) (“Klimesch-2003”)).

11. TMS involves the use of magnets and magnetic fields applied to the head of a subject—“magnets” are simply the devices that generate the magnetic field and thereby the “magnetic stimulation” or “transcranial magnetic stimulation.” While, in theory, either permanent or electromagnets could be used, in practice, most TMS machines use electromagnets..<sup>11</sup> Similarly, in practice, the magnets must be placed directly on, or very close to, the head of a subject (within a few inches), because the physics of magnetic fields (specifically, the inverse-square law) causes the strength of the magnetic field to weaken proportional to the square of the distance between the target (the brain) and the magnet. Thus, absent extraordinary circumstances, it is almost always preferable to place the magnet (or magnetic coil generator) as close as possible to the head of the patient, if not on the head.

12. The use of magnetic fields with strengths in the range described by the Asserted Patents (10 Gauss to 4 Tesla— which are the units used to define the strengths of magnets) was widely known and in common use prior to the earliest possible priority date of the Asserted Patents, September 2007.<sup>12</sup>

13. As discussed above, the application of electromagnetic fields (EMFs) to the brain and assessment of changes in the brain’s electrical activity due to those fields can be measured using EEGs, and this process has been extensively described since at least the 1970s.<sup>13</sup>

---

<sup>11</sup> See, e.g., Ex. 14 (U.S. Pat. App. Pub. 2005/0256539A1 (Nov. 17, 2005) (“George”) (reciting both “permanent magnet(s)” and “current pulse” a/k/a electromagnets at ¶ 0127))

<sup>12</sup> See, e.g., Ex. 15 (*Yi Jin et al., Therapeutic Effects of Individualized Alpha Frequency Transcranial Magnetic Stimulation ( $\alpha$ TMS) on the Negative Symptoms of Schizophrenia*, 32 SCHIZOPHRENIA BULLETIN 556 61 at 556 (Oct. 27, 2005) (“Intensity—Generally quantified for each individual as a percentage of the threshold at which motor activity can be elicited (~1-2 Tesla)”) (“Jin-2005”)).

<sup>13</sup> See, e.g., Ex. 8 (Gavalas); Ex. 9 (Bawin); Ex. 10 (Bell).

14. TMS has been in use as a research and therapeutic technique since at least 1985.<sup>14</sup> TMS was originally administered as a single pulse, meaning the magnetic field was administered in a single pulse with a specific duration, called the pulse width. However, in the early 1990s, multiple pulses began to be administered in repeated bursts. Repeated pulses became known as “rapid” or “repetitive” TMS a/k/a “rTMS.”

15. Mathematically, any repeated series of events-including the magnetic field pulses of rTMS-inherently has a measurable “frequency.” Frequency is simply the measurement of how often the events occur and, with respect to rTMS, is measured in pulses per second (“pps”), the scientific unit of which is Hertz (“Hz”). One Hz means 1 pulse per second, 10 Hz means 10 pulses per second, and so on. In the context of EEG measurements, ranges of frequencies are commonly referred to as “frequency bands.” However, a TMS machine stimulates only a single frequency at a time, not an entire frequency band.

16. Generally, to use a TMS device, it needs to be configured by selecting certain operational characteristics, including the frequency of the magnetic pulse. Early on, rTMS was administered at a variety of frequencies, including, but not limited to, .25 Hz, .5 Hz, 5 Hz, 10 Hz, and 20 Hz.<sup>15</sup>

---

<sup>14</sup> See Ex. 16 (Horvath, Jared C. et al, *Transcranial Magnetic Stimulation: A Historical evaluation and future prognosis of therapeutically relevant ethical concerns*, 37 JOURNAL OF MEDICAL ETHICS 137-43 (“Horvath 2011”).

<sup>15</sup> See Ex. 13 (Klimesch-2003); Ex. 16 (Horvath 2011); Ex. 17 (Lisanby, Sarah H., *Transcranial Magnetic Stimulation in Psychiatry: historical reflections and future directions*, 19 BIOLOGICAL PSYCHIATRY 486-90 (Mar. 15, 2024)).

17. The ultimate clinical goal of TMS and rTMS is and has been to treat or provide relief from symptoms of mental illness, and otherwise to improve cognitive function. rTMS has been used to treat depression and schizophrenia since at least 1997.<sup>16</sup>

18. In 2003, several years before the priority date of the Asserted Patents, *Klimesch et al.* published *Enhancing cognitive performance with repetitive transcranial magnetic stimulation at human individual alpha frequency*. European Journal of Neuroscience, Vol. 17, pp. 1129-1133, 2003 (Ex. 13, “*Klimesch-2003*”). *Klimesch-2003* describes rTMS experiments where he initially measured the subject’s intrinsic alpha frequency (“IAF”) and then administered rTMS therapy at that measured frequency + 1 Hz. During these experiments, he also administered, as a control condition, rTMS at other frequencies at a variety of frequencies below IAF (*e.g.*, IAF - 5 Hz, IAF - 3 Hz, etc.) See Ex. 13 (*Klimesch-2003* at 1132 (page 4 of PDF)). This research shows that rTMS was known and used years before the priority dates of the Asserted Patents as a treatment for various symptoms, and that it was administered both at patients’ intrinsic frequencies (*e.g.*, “TMS at IAF”) and at other pre-selected frequencies in the alpha band or sub-bands near IAF. To be clear, while TMS can be applied within a frequency band, it cannot stimulate an entire frequency band simultaneously. In other words, TMS can be administered at 10 Hz, which is a specific frequency *within* the alpha band of frequencies. However, TMS cannot be administered to or at an entire band of frequencies simultaneously.

19. Taking the EEG of a patient before and after the patient undergoes TMS therapy, or other types of brain entrainment such as EMF exposure or photic stimulation, was also well known at the time of the Asserted Patents. For example, as discussed above, the Adrian and

---

<sup>16</sup> Ex. 18 (Geller et al., *Slow Magnetic Stimulation Of Prefrontal Cortex In Depression and Schizophrenia*, 21 PROGRESS IN NEURO-PSYCHOPHARMACOLOGY & BIOLOGICAL PSYCHIATRY 105-10 (1997)).



Matthews work in 1934 investigating the effects of visual-entrainment on brain activity used EEGs to study the resultant entrainment, as did the 1970s and later studies on electromagnetic fields and their effect on the human brain.<sup>17</sup>

20. Another example in 2005 was conducted by Dr. Jin—one of the named inventors on the Asserted Patents. In this study, each treatment consisted of ten daily sessions during a 2-week period. The stimulation was given for two seconds per minute for twenty consecutive minutes per session, and the frequencies for the active stimuli were in the alpha frequency range and were determined at the nearest integer of each patient’s average alpha peak frequency, obtained using EEGs. The EEGs were administered at screening, immediately prior to first treatment, immediately following the fifth and tenth treatments, and at the end.<sup>18</sup> While it is unclear from the reporting whether the researchers actually changed the rTMS frequency between sessions, because the treatment was to be administered at the subject’s individualized alpha frequency, the study inherently teaches that the rTMS treatment changes ( or “tunes”) the individualized alpha frequency, and the study teaches that the patient’s EEGs were retaken during the study—which would result in a new measurement of individualized alpha frequency. This study inherently teaches the process of adjusting the administered frequency in response to EEG measurements taken after rTMS is administered to the subject.

21. One concept that frequently occurs in the literature relating to EEG and rTMS is peak alpha frequency (“PAF”), which generally refers to the frequency at which the alpha rhythm oscillates over a given period. PAF is referred to by a variety of different terms and definitions in the scientific literature including, but not limited to, individualized alpha frequency (“IAF”),

---

<sup>17</sup> See *supra* Footnote 8.

<sup>18</sup> Ex. 15 (Jin) at 557-58.

“mean frequency,” “intrinsic frequency,” “intrinsic alpha frequency,” and others. PAF can be calculated using various methods, ranging from counting the number of oscillations or peaks in the alpha wave over a short interval to computing the “center of gravity” of recorded EEG alpha activity, which provides a more precise measure.<sup>19</sup> In the context of the Asserted Patents, these terms can be used interchangeably, as confirmed by the specifications of the Asserted Patents, which describe the patient (or subject)’s “intrinsic frequency” or “intrinsic alpha frequency” as “[t]he vertical line drawn through the peaks is at 9.1 Hz, the subject’s intrinsic alpha frequency.” See ’408 Patent, 15:5-15; ’490 Patent, 21:42-52; and ’737 Patent, Fig. 12 and 19:52-62.

22. As noted in Klimesch 1999,

Frequency and power are closely interrelated measures. Usually, alpha frequency is defined in terms of peak or gravity frequency within the traditional alpha frequency range (f1 to f2) of about 7.5-12.5 Hz. Peak frequency is that spectral component within f1 to f2 which shows the largest power estimate. Alpha frequency can also be calculated in terms of gravity (or “mean”) frequency which is the weighted sum of spectral estimates, divided by alpha power.

(cleaned up, equations omitted, citations omitted.)<sup>20</sup>

23. In humans, alpha frequency increases with age from about 5.5 Hz at age 1-3, to about 10 Hz at age 15.<sup>21</sup> As noted above, human brains do not exhibit a *single* brainwave frequency—they are always simultaneously producing brainwaves at many frequencies such as alpha, delta, and theta, and the frequencies can change from moment to moment. IAF, PAF, and other quantities are attempts to measure and characterize a “central,” “peak,” “dominant,” or

---

<sup>19</sup> See Ex. 19 (McLain, Natalie J. et al., *Analytic Consistency and neural correlates of peak alpha frequency in the study of pain*, 368 JOURNAL OF NEUROSCIENCE METHODS 3-4 (2021)) (surveying papers using different techniques including COG and peak picking to determine PAF).

<sup>20</sup> Ex. 20 (Klimesch, Wolfgang, *EEG Alpha and Theta Oscillations Reflect Cognitive and Memory Performance: a review and analysis*, 29 Brain Research Reviews, 169-95 (1999) (“Klimesch 1999”)) at 172.

<sup>21</sup> Ex. 20 (Klimesch 1999) at 175.

otherwise characteristic frequency; but in reality, different brains are generating a multitude of intrinsic frequencies. This is evident in real-world EEG readings, which, when translated into the frequency domain, display one or more peaks, each representing an intrinsic frequency characteristic of specific brain regions. Thus, because of the inherent properties of human brainwaves, *any* administration of rTMS at a particular frequency (at 10 Hz, for example, thus in the alpha band) will inherently be simultaneously: (i) at an intrinsic frequency of the brain, (ii) above a different intrinsic frequency of the brain, and (iii) below a different intrinsic frequency of the brain.

### **BRAINWAVE ENTRAINMENT USING rTMS**

24. As discussed above, brainwave entrainment refers to the observation that brainwaves (large-scale electrical oscillations in the brain) will naturally synchronize to the rhythm of periodic external stimuli. This process is the natural phenomena that when the brain is repeatedly stimulated at a particular frequency, the frequency(ies) of the brainwaves will change to match (or attempt to match) the stimulation in frequency and phase. Matching frequency means that the frequency of the brainwaves will attempt to match the frequency of the stimulus. Matching phase means that the peaks and troughs of the brainwaves wave will move to align with (or become “in phase with”) the external stimulation wave. This phenomenon is also referred to as coherence or synchronization. Thus, if an intrinsic frequency of the subject is at a particular frequency  $f_1$ , and a stimulation is applied at frequency  $f_2$ , entrainment will cause the intrinsic frequency of the subject to move towards matching  $f_2$ , and the peaks and troughs of the brainwaves will also move towards alignment, matching in phase. Brainwave entrainment occurs when the brain is stimulated with

any rhythmic stimulus, including, but not limited to, flickering lights,<sup>22</sup> speech,<sup>23</sup> music,<sup>24</sup> or, as in this case, rTMS pulses. “Synchronization of oscillatory activities in distributed neural assemblies is a well-studied mechanism in the working of the brain .... Early in the history of human brain physiology it was demonstrated that brain activities could also synchronize to external stimuli.”<sup>25</sup> rTMS was known to entrain brainwave frequencies years before the priority date of the Asserted Patents. In a 2001 paper by *Okamura et al.* in the Journal of Clinical Neurophysiology, researchers published scientific evidence showing that when rTMS at 10 Hz was applied to a subject whose PAF (measured via EEG) was less than 10 Hz, the PAF of the subject rose to 10 Hz or more.<sup>26</sup>

---

<sup>22</sup> Ex. 6 (Adrian and Matthews); *see also* Ex. 21 (Notbohm, Annika et al., *Modification of Brain Oscillations via Rhythmic Light stimulation Provides Evidence for Entrainment but Not for Superposition or Event-Related Responses*, 10 FRONTIERS IN HUMAN NEUROSCIENCE Article 10 (2016)).

<sup>23</sup> Ex. 22 (Ding, Nai et al., *Cortical entrainment to continuous speech: functional roles and interpretations*, 8 FRONTIERS IN HUMAN NEUROSCIENCE Article 311 (2014)).

<sup>24</sup> Ex. 23 (Thaut, Michael H. et al., *The discovery of human auditory-motor entrainment and its role in the development of neurologic music therapy*, 217 PROGRESS IN BRAIN RESEARCH Chap. 13, 253-66 (2015)).

<sup>25</sup> Ex. 7 (Will & Berg).

<sup>26</sup> Ex. 24 (Okamura, Hisataka et al., *EEG Modification Induced by Repetitive Transcranial Magnetic Stimulation*, 18 JOURNAL OF CLINICAL NEUROPHYSIOLOGY 318-25 (2001) (“Okamura”)).

Channel	Before rTMS	0–1 min after rTMS	1–2 min after rTMS
F3	8.413 ± 1.384	10.33 ± 0.419 <sup>†</sup>	10.26 ± 0.355 <sup>†</sup>
F4	8.570 ± 1.479	10.15 ± 0.565 <sup>†</sup>	10.15 ± 0.488 <sup>†</sup>
C3	8.878 ± 1.336	10.22 ± 0.512*	10.18 ± 0.402*
C4	9.228 ± 1.298	10.13 ± 0.598	10.14 ± 0.496
P3	9.458 ± 1.434	10.22 ± 0.767	10.34 ± 0.375
P4	9.549 ± 1.432	10.26 ± 0.817	10.25 ± 0.756
T3	9.095 ± 1.169	10.68 ± 1.302 <sup>†</sup>	10.60 ± 1.242 <sup>†</sup>
T4	9.369 ± 1.296	10.78 ± 1.774 <sup>†</sup>	10.78 ± 2.091 <sup>†</sup>
T5	9.457 ± 1.599	10.32 ± 0.607	10.21 ± 0.440
T6	9.443 ± 1.189	10.37 ± 0.518	10.38 ± 0.708
Fz	8.509 ± 1.445	10.23 ± 0.475 <sup>†</sup>	10.20 ± 0.442 <sup>†</sup>
Cz	8.834 ± 1.256	10.15 ± 0.589*	10.20 ± 0.444*
Pz	9.418 ± 1.402	10.16 ± 0.675	10.25 ± 0.366
Oz	9.701 ± 1.455	10.50 ± 0.428	10.39 ± 0.456

Data are shown as mean ± standard deviation.

\* 0.01 < *P* < 0.05.

<sup>†</sup> *P* < 0.01 (compare with the results calculated before rTMS).

rTMS, repetitive transcranial magnetic stimulation.

*Table 2 from Okamura-2001.*

25. As shown in the above excerpt of *Table 2* from *Okamura-2001*:

- a. Before TMS therapy, the subject had a number of intrinsic frequencies at different channels (*e.g.*, the intrinsic frequency on channel F3 was 8.413 Hz).
- b. Then, according to the experimental protocol, rTMS was applied at 10Hz.  
*See Okamura-2001, Summary.*
- c. Then, according to the experimental protocol, the subject's intrinsic frequencies were measured again. The subject's intrinsic frequency (again on top row, recording channel F3) was 10.33 Hz at the time period 0-1 minutes after rTMS, and 10.26 Hz 1-2 minutes after rTMS.

26. *Okamura's* published scientific research shows that, years before the priority date of the Asserted Patents, the natural law and phenomenon of brainwave entrainment through rTMS was known, practiced, and published; and that so-called “methods” of modifying brain characteristics (such as intrinsic frequencies or phase) through the use of rTMS pulses is simply the body's natural and expected physiological response to external stimuli.

27. In other studies, *e.g.*, *Jin-2005*, the same effect—*i.e.* changing certain characteristics of the brain such as intrinsic frequencies with the application of rTMS—is referred to as “tuning.” The ability to “tune” brain states was experimentally verified. *See* Ex. 15 (*Jin-2005*) (“It was proposed that the resonance ‘tuning’ of the peak alpha oscillations would serve to increase the power density in this frequency range and thereby improve negative symptoms. The results have provided support for these hypotheses ....”) This effect of rTMS on the brain is simply entrainment—the natural law or inherent physiological reaction of the brain tissues to stimulation at various frequencies—and is referred to variously in the literature as “entrainment,” “driving,” “adjusting,” or “moving” the brain characteristics.

28. Thus, it was a well-known, published, scientific fact that when rTMS is administered to the brain of a subject, the subject’s intrinsic frequency will move in the direction of the frequency of the rTMS administered. Further scientific studies have confirmed this result.<sup>27</sup>

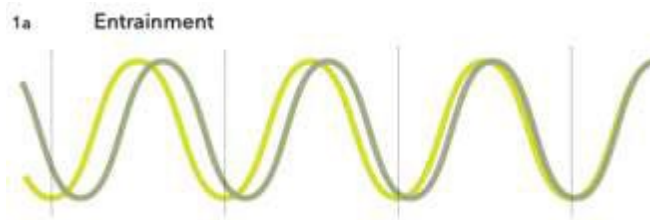
29. This result is not limited to changing the subject’s intrinsic frequency; it extends to other characteristics of the subject’s brainwaves, such as the EEG phase.<sup>28</sup> Certain claims of the Asserted Patents substitute “EEG phase” for “intrinsic frequency” as the brain characteristic driven, moved, or adjusted by rTMS therapy. However, as discussed throughout, this is simply another example of the natural law of neurological entrainment. Entrainment is not the result of a particular machine or process—it is simply the natural response of the human brain to external stimulation. That natural response includes, among other things, that a rhythmic stimulation applied to the brain (be it rTMS, flickering lights, auditory stimulation, or other means) induces

---

<sup>27</sup> *See, e.g.*, Ex. 25 (Thut, Gregor et al., *Rhythmic TMS causes local entrainment of natural oscillatory signatures*, 21 CURRENT BIOLOGY 1176-85 (2011)).

<sup>28</sup> *See, e.g.*, Ex. 26 (Faller, Josef et al., *Daily prefrontal closed-loop repetitive transcranial magnetic stimulation (rTMS) produces progressive EEG quasi-alpha phase entrainment in depressed adults*, BRAIN STIMUL. (2022)).

the brainwaves to match that rhythm. One aspect of the matching process is frequency, where the frequency of brainwaves moves in the direction of the external rhythm frequency. Another aspect is phase, where the “beats” or peaks and troughs of those brainwaves move to synchronize with the external rhythm. EEG measures both aspects. When EEG alpha activity becomes entrained with the external stimulation, the phase of the alpha becomes synchronized to the phase of the stimulation, with an end-result that the quantified IAF/PAF becomes the same as the externally applied stimulation, as depicted in the diagram below.



*Exemplary Figure*

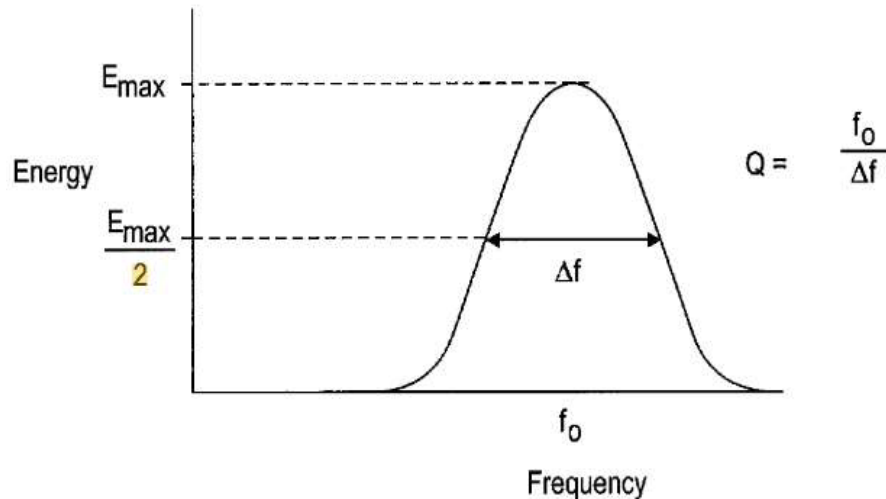
30. Figure 1a above demonstrates the concept of entrainment, where in the beginning the light green signal is 8.9 Hz, but with external entrainment with the dark green external 9 Hz signal the frequencies become identical towards the end, and the phase for both signals becomes entrained. This demonstrates how frequency and phase are intrinsically connected within the concept of entrainment, representing complementary aspects of the same phenomenon.

31. Certain claims of the Asserted Patents replace “intrinsic frequency”—the brain characteristic to be “moved” or “tuned” by rTMS therapy—with a term defined by the inventor as “q-factor.” Q-Factor is a generic concept in physics and engineering, typically understood to relate to the “quality” of a resonating or oscillating circuit.<sup>29</sup> Outside of the Asserted Patents, Q-factor is

<sup>29</sup> See Ex. 27 (Tooley, Michael, *Electronic Circuits, Fundamentals and Applications*, at 74-75 (Newnes 2d. ed. 2002) (“Quality factor; The quality of a resonant (or tuned) circuit is measured by its Q-factor. The higher the Q-factor, the sharper the response (narrower bandwidth), conversely the lower the Q-factor, the flatter the response (wider bandwidth).”).

uncommonly used in EEG or psychophysiology; though it had been studied, experimented upon, and published before the priority date of the Asserted Patents.<sup>30</sup> The Asserted Patents appear to use it to quantify the amount of resonance resulting from rTMS or, in other words, how well the brain is actually entraining.

32. In the Asserted Patents, Q-Factor is defined by reference to Fig. 12 as follows: “The Q-factor is defined as the ratio of  $f_0 / \Delta f$ . As can be seen, when  $\Delta f$  decreases for a given  $f_0$ , the q-factor will increase. This can occur when the peak energy  $E_{\max}$  of the signal increases or when the bandwidth of the EEG signal decreases.”



<sup>30</sup> See Ex. 28, (Jin, Yi et al., *Alpha EEG Selectivity Predicts Efficacy Of RTMS In Schizophrenia*, ABSTRACTS OF THE XX INTERNATIONAL CONGRESS ON SCHIZOPHRENIA RESEARCH at 455 (2005) (“The selectivity of a resonant system can be described by quality factor, Q. For small damping it can be identified with  $Q = f_p/(f_1-f_2)$ , where  $f_p$  is the resonant frequency, and  $f_1-f_2$  is a half-power bandwidth (HPB) around the resonance. . . . rTMS rate was set at the alpha EEG resonant frequency. . . . Clinical symptoms and EEG were evaluated at baseline and after 10 treatments at each condition. . . . Analysis of EEG at Fz revealed a significant increase in alpha EEG selectivity ( $Q = 2.60$  . . .) after the active rTMS as compared with baseline ( $Q = 2.17$  . . .). Using 11 cases who had completed both EEG and clinical evaluations, we found that the clinical improvement in negative symptoms was significantly correlated with the degree of increase in Q-factor . . . . These data provide evidence that human alpha EEG can be tuned by direct electromagnetic stimulation.”)).



'408 Patent, Fig. 12 and 15:49-59; '490 Patent, Fig. 12 and 22:19-29; '737 Patent, Fig. 12 and 20:31-41.

33. In other words, Q-factor is the ratio of the frequency  $f_0$  (where peak power resides) to the width of the wave at  $E_{\max} / 2$  (*i.e.*, bandwidth at half peak power). If the wave stays the same width but the power increases, Q-factor goes up. If the power goes down and the width stays the same, Q-factor goes down.

34. As discussed above, the natural physiological response of the brain to rhythmic stimulation (*i.e.*, entrainment) is for the brainwaves to move towards or match the applied stimulus. Given the Asserted Patents' definition of Q-factor, the natural phenomenon of neural entrainment implies that as entrainment of the brainwaves is achieved, the amplitude of the entrained frequency generally goes up (as previously time-separated pulses overlap, their amplitudes are added together), and the width of the band ( $\Delta f$  at  $E_{\max} / 2$ ) generally decreases due to the effect of the synchronized alpha waves. Thus, the Q-factor (under the Asserted Patents' definition) must inherently go up.

35. As noted above, this finding was experimentally confirmed and published before the priority date of the Asserted Patents.<sup>31</sup> Scientists (including one of the inventors of the Asserted Patents) administered rTMS at the subject's "peak frequency," and "clinical symptoms and EEG were evaluated at baseline and after." The results indicated that the Q-factor increased (from 2.17 to 2.6) and that "clinical improvement in negative symptoms was predicted by the degree of increase in Q-factor."

---

<sup>31</sup> See, *e.g.*, Ex. 29 (Jin, Y. et al., *Improvement in Alpha EEG Selectivity and Negative Symptoms in Schizophrenia Following rTMS Treatment*, 35:4 CLINICAL EEG & NEUROSCIENCE 224-25 (Wheaton 2004)).

### **CONTROL OF rTMS MACHINES**

36. Existing rTMS machines sold in the United States prior to 2007 used processors to control the firing of the magnetic field. For example, the MagVenture R30 contained a processor which allowed the user to set and administer various frequencies, field strengths, pulse trains, durations, and other characteristics of the rTMS therapy on the machine itself. In addition, this machine was, and is, configured with a data port (a/k/a COM2) which allows it to be controlled by an *external* computer or processor.<sup>32</sup>

### **ANALYSIS OF THE ASSERTED CLAIMS**

37. I am informed by Defendant's counsel that, in the present action, the "Asserted Claims" of the Asserted Patents are:

- a. Claims 1 – 4, 8, 9, and 11 of the '737 Patent;
- b. Claims 1 – 4, 9, 10, 12, and 20 of the '408 Patent; and
- c. Claims 1 and 9 of the '490 Patent.

38. I address each of the Asserted Claims below. In summary, it is my opinion that each of the Asserted Claims is directed to the natural phenomenon of brainwave entrainment through the use of TMS.

### **Claims 1 – 4, 8, 9, and 11 of the '737 Patent**

39. Independent Claims 1 and 2 of the '737 Patent each recite a generic TMS device and related concepts, which were all well known in the TMS community before 2007 as discussed herein. These include electromagnets, magnetic fields, processors, intrinsic frequencies, and EEG bands. As discussed above, rTMS devices were well known prior to the Asserted Patents, and all TMS devices from that time have magnets (almost all of which are electromagnets), magnetic

---

<sup>32</sup> Ex. 30 (MagVenture 3/13/2024 Depo. Tr.) at 64:20-67:15.

fields, and processors. Likewise, all healthy human brains have intrinsic frequencies within specific EEG bands. Thus, structurally, Claims 1 and 2 contain nothing that was not well known and in common use prior to the time of the patent.

40. Claims 1 and 2 claim each a method (or the process) of using the foregoing generic TMS device for “adjusting output of a magnetic field” and thereby “moving, using the magnetic field” “an intrinsic frequency of a specified EEG band of the subject toward a pre-selected intrinsic frequency of the specified EEG band” or, for claim 1 only, “a Q-factor of an intrinsic frequency within a specified EEG band of the subject toward a pre-selected Q-factor.” Both claims thus squarely cover the natural phenomenon of brainwave entrainment, *i.e.*, moving the brain’s intrinsic frequency via exposure to a rhythmic stimulus such as a magnetic field. Applying rTMS using electromagnets positioned close to the head is inherent in this technology as explained above in par. 11.

41. One aspect of both claims involves “pre-selecting” a target intrinsic frequency or Q-factor. As discussed above, using a TMS device inherently involves setting a frequency for it to operate at, and that setting is done *before* the machine is activated to administer therapy to the patient. Thus, any use of a TMS device inherently involves a “pre-selected” frequency or “Q-factor.” This is also specifically disclosed in *Yin-2005*. Specifically, the “Procedure” section confirms that EEG was taken before the rTMS treatment and that the treatment frequency was individualized based on the EEG results. *Yin-2005* at pg. 557. Specifically, it states that “[t]he frequencies for the active stimuli were 3 Hz, individualized alpha (8–13 Hz) and 20 Hz. Rate for the alpha frequency stimulation was determined at the nearest integer of each patient’s average alpha peak frequency, obtained from 5 frontal EEG leads (F7, F3, Fz, F4, F8).” *Id.* (emphasis added). Notably, I understand that the Court has construed the term “the intrinsic frequency” as

“frequency at which peak signal power is located to which treatment is to be applied.” This confirms my understanding that the patient’s average alpha peak frequency is what is referred to as the intrinsic frequency in the Asserted Patents. Similarly, this technique is also disclosed in *Klimesch-2003*, which describes rTMS experiments where he initially measured the subject’s intrinsic alpha frequency (“IAF”) using EEG and then administered rTMS therapy at a “pre-selected / target frequency” of that measured frequency + 1 Hz. During these experiments, he also administered, as a control condition, rTMS at other frequencies at a variety of frequencies below IAF (*e.g.*, IAF - 5 Hz, IAF - 3 Hz, etc.) See Ex. 13 (*Klimesch-2003* at 1132 (page 4 of PDF)). This research shows that rTMS was known and used years before the priority dates of the Asserted Patents as a treatment for various symptoms, and that it was administered both at patients’ intrinsic frequencies (*e.g.*, “TMS at IAF”) and at other pre-selected frequencies in the alpha band or sub-bands near IAF. Thus, using an EEG to determine a patient’s intrinsic frequency, and pre-selecting a frequency based on that measurement to use during treatment was well known in the art.

42. Similarly, as discussed above, the administration of rTMS, as known before the Asserted Patents, necessarily resulted in “moving” an intrinsic frequency to a pre-selected value (*i.e.*, the frequency to which the machine is set) because this is the natural physiological result of brainwave entrainment in response to TMS. This was actually done and documented before the Asserted Patents by the scientists cited above, including, for example, *Okamura*. Indeed, because entrainment is a natural physiological response to external stimuli such as TMS, use of rTMS in the alpha band *necessarily* results in at least short-term entrainment of the patient’s brainwaves to the stimulating frequencies, as demonstrated for example by *Okamura*. Thus, any administration of rTMS in the alpha band will result in “moving” that intrinsic frequency or Q-Factor to or toward the frequency or Q-Factor at which the machine is set.

43. I note further that the “intrinsic frequency” and Q-Factor” elements of Claim 1 of the ’737 Patent are limiting only in the alternative, *i.e.*, the claim requires moving “at least one of” “an intrinsic frequency” *or* “a Q-factor.” As discussed above, both alternatives are simply aspects of the same natural phenomenon of brainwave entrainment: when an external rhythmic stimulation is administered to the human brain, the brainwaves will become entrained in frequency and phase. As a result, the Q-factor (as defined by the Asserted Patents) will increase as a result of the synchronization of the brain’s alpha rhythms with frequency of rTMS. This was confirmed, for example, in Jin, Y. *et al.*, *Improvement in Alpha EEG Selectivity and Negative Symptoms in Schizophrenia Following rTMS Treatment*, 35:4 CLINICAL EEG & NEUROSCIENCE 224-25 (Wheaton 2004).

44. The claims further list the inherent effects of movement of the intrinsic frequency (or related Q-Factor): “wherein the pre-selected intrinsic frequency is a frequency that increases (claim 1) or decreases (claim 2) blood flow in the cortex of the subject” and, for claim 1 only, “wherein the pre-selected Q-factor is a Q-factor that increases blood flow in the cortex of the subject.” The claim language explicitly cites a known effect: either increasing the intrinsic frequency (or Q-Factor) to increase blood flow in the cortex of the subject (claim 1), or decreasing the intrinsic frequency to decrease blood flow (claim 2). Further, together, the two claims claim all possible outcomes of applying *any kind of magnetic field* to the head of a subject, *i.e.*, either increasing or decreasing the intrinsic frequency (and thereby the Q-Factor, which is defined using the intrinsic frequency).

45. Thus, for the reasons discussed above, it is my opinion that Claims 1 and 2 of the ’737 Patent are directed to the natural law and abstract idea of brainwave entrainment through the

use of rTMS. Further, Claims 1 and 2 add no technology, innovation, or inventive concept to that natural law which was not already known in the art before the priority date of the Asserted Patents.

46. Regarding dependent claims 3, 4, 8, 9, and 11, none add any non-trivial idea or concept to this analysis. Claim 3 adds taking an EEG measurement before and/or after applying the magnetic field to monitor the intrinsic frequency / Q-Factor, which was known. *See* Adrian and Matthews, 1934. Claim 4 adds “determining” the intrinsic frequency or Q-Factor, which is inherent in claims 1 and 2 to detect movement thereof. Claim 8 adds the time period of applying the field, which was known. *Jin-2005*. Claim 9 adds repeating the process, which was also known. *See* par. 14 *supra*. Claim 11 specifies improving depression symptoms, as measured by HAMD scores through rTMS, which was known. *Jin-2005*. The dependent claims do nothing more than recite well understood conventional steps that were known in rTMS.

#### **Claims 1 – 4, 9, 10, 12, and 20 of the ’408 Patent**

##### **Method Claims 1 – 4, 9, and 10**

47. Independent method Claim 1 of the ’408 Patent is even broader than claims 1 and 2 of the ’737 Patent and recites generic application of brainwave entrainment that is a natural phenomenon that was well known before the time of the Asserted Patents.

48. Claim 1 claims only treating various conditions by “adjusting a setting of a magnetic field” that is “configured to move *one or more* of an intrinsic frequency, a Q-Factor, a coherence value, or an EEG phase” and then “applying said magnetic field close to the head of a subject.” That, of course, is tantamount to the definition of brainwave entrainment—applying *any* magnetic field close to the head of a subject necessarily moves phase and frequency of the intrinsic frequency of the subject, and thereby inherently also changes the Q-factor and coherence value.

49. The EEG phase is also a characteristic of brainwaves that is naturally entrained by the external stimulation of rTMS, like intrinsic frequency and Q-factor. *See* par. 29 (fn. 29) *supra*.

Further, as explained in par. 24 *supra*, matching the phase means that the peaks and troughs of the brainwaves wave will move to align with (or become “in phase with”) the external stimulation wave, which is a phenomenon referred to as coherence or synchronization. The fact that claim 1 refers to this as “coherence value” does not change this natural concept.

50. Notably, the elements relating to “intrinsic frequency,” “Q-Factor,” “coherence value,” “EEG phase,” “or a combination thereof”) are limiting only in the alternative—the claim requires moving only “one or more” of them. As discussed above, these alternative elements are simply other aspects of the natural law of brainwave entrainment: when an external rhythmic stimulation is administered to the human brain, the brainwaves will become entrained, in frequency and phase. As a result, the Q-factor (as defined by the Asserted Patents) will necessarily change as a result of the synchronization of the brain’s alpha rhythms with frequency of rTMS.

51. Claim 1 further claims “wherein the magnetic field comprises one or more magnetic field generators that are of the same frequency and are in-phase with each other, of the same frequency and out of phase with each other, or a combination thereof.” This limitation is meaningless. Any two signals that are of the same frequency, whether they are magnetic fields, light waves, or audio waves, must necessarily be either “in-phase with each other, out of phase with each other, or a combination thereof.” Thus, this limitation simply boils down to two magnetic fields of the same frequency. Applying two magnetic fields at the same frequency to the head of a subject in rTMS was well known prior to the priority date of the Asserted Patents. *See, e.g.,* Ex. 31 (Medtronic MCF-Coils User Guide). This is the user manual for a line of rTMS coils including the MCF-B65, which contains two separate windings, each generating its own magnetic field, both at the same frequency.



MCF-B65

52. Independent method Claim 2 similarly recites treating several conditions by “moving” an intrinsic frequency or Q-Factor “by applying a magnetic field close to a head of the subject” comprising a single target frequency, or a plurality of frequencies, or the intrinsic frequency. This limitation, in other words, covers any frequency or combination of frequencies. Both claims again effectively claim only the natural phenomenon of brainwave entrainment, and the difference, relating to using either one frequency or any combination of frequencies is immaterial. This again simply implicates the natural phenomenon of brainwave entrainment, since subjecting the human brain to a magnetic field inherently causes brain entrainment.

53. Thus, for the reasons discussed above, it is my opinion that Claims 1 and 2 of the ’408 Patent are directed to the natural law and abstract idea of brainwave entrainment through the use of rTMS. Further, Claims 1 and 2 of the ’408 Patent add no technology, innovation, or inventive concept to that natural law which was not already known in the art before the priority date of the Asserted Patents.

54. Regarding dependent claims 3, 4, 9, and 10, none add any non-trivial idea or concept to this analysis. Claim 3 adds taking an EEG measurement before and/or after applying the magnetic field to monitor the intrinsic frequency / Q-Factor, which was known. *See* Adrian



and Matthews, 1934. Claim 4 adds adjusting the magnetic field based on the EEG, which was known. In other words, Claim 8 seeks to claim the step of administering rTMS, taking an EEG measurement to see if it worked, adjusting the treatment, and trying again—the basis for many medical treatments, and taught specifically in *Jin-2005* as discussed above. Claim 9 adds the time period of applying the field, which was known. *Jin-2005*. Claim 10 adds repeating the process, which was also known. *See par. 14 supra*. The dependent claims do nothing more than recite well understood conventional steps that were known in rTMS.

#### System Claims 12 and 20

55. Independent system claim 12 merely implements parts of the method of claim 1 using a computer system comprising only known components, *i.e.*, computer means comprising a first (and optional second) computer processor for controlling a magnetic field and applying said magnetic field close to the head of a subject. '408 Patent, claim 12. The system components add nothing novel to the claimed invention, and literally serve only to implement the very method of claim 1, which in turn comprises only the natural phenomenon of brainwave entrainment using a magnetic field as previously explained.

56. Dependent system Claim 20 only adds logic able to calculate the intrinsic frequency or Q-Factor from the EEG data. From the perspective of the relevant field of technology, there is nothing novel in this determination.

#### **Claims 1 and 9 of the '490 Patent**

57. Independent Claim 1 merely claims the natural phenomenon of brainwave entrainment using rTMS to treat depression, as implemented using computer equipment. It first recites “a magnetic field generator adapted to apply a magnetic field to a head of the subject.” This is inherent in rTMS treatment. *See supra*, par. 11. Claim 1 further recites that the “magnetic field generator comprises a non-transitory computer readable medium” and “a processor,” both

components known in the art of existing rTMS machines. The non-transitory computer readable medium stores a “subject data value” which comprises a subjects intrinsic frequency, a Q-factor, a coherence value between two intrinsic frequencies from two different sites in the brain, or an EEG phase between two different sites in the brain. How to derive these values from an EEG was known. *See supra*, par. 8; *see also* Dkt. 32-5 (Bikson Dec.) at ¶61 (“Each subject has their own internal, *i.e.* intrinsic, frequency which can be measured by an EEG.”) The EEG phase is another characteristic of brainwaves which is naturally entrained by the external stimulation of rTMS), like intrinsic frequency and Q-factor. *See supra*, par. 29. The processor controls the magnetic field to “move the first intrinsic frequency in a pre-selected direction, up or down,” “move the Q-factor of the first intrinsic frequency in a pre-selected direction, up or down”, “move the coherence value” or “move the EEG phase of the specified EEG frequency.” Finally, because all human intrinsic frequencies are inherently within “an EEG band,” the “EEG band” limitation is meaningless (as discussed above). This means that claim 1 effectively claims merely the natural phenomenon of brainwave entrainment executed using a computer system.

58. The claim further lists the automatic known effects of that movement of the intrinsic frequency and related Q-Factor: “wherein the magnetic field increases the blood flow of a cortex of the brain or decreases the blood flow of a lower region of the brain.” ’490 Patent, claim 1. Notably, the claim hedges its bets by claiming “wherein the magnetic field increases the blood flow of a cortex of the brain or decreases the blood flow of a lower region of the brain.” This ambiguity renders this claim limitation meaningless. It simply observes a known effect, that changes in the magnetic field affect the blood flow in the region of the brain to which it is applied.

59. Dependent Claim 9 only adds standard computer logic to “calculate the subject data value from EEG data” without disclosing how to do so. This merely implements a known method on known standard computer logic.

60. Thus, it is my opinion that Claims 1 and 9 of the '490 Patent are directed to the natural law and abstract idea of brainwave entrainment through the use of rTMS. Further, Claims 1 and 9 add no technology, innovation, or inventive concept to that natural law which was not already known in the art before the priority date of the Asserted Patents.

I declare under penalty of perjury under the laws of the United States of America that the testimony provided herein is true and correct to the best of my ability.

**Executed on:** February 6, 2025

**By:**

Dr. Jared Dempsey

